Compressed Gas Risk Assessment Standard

Contents

1.0 Introduction 2
2.0 Risk assessment for any activity involving compressed gases 2
2.1 Risk Assessment 2
2.2 Manifold/ Fixed Gas systems 2
2.3 Mobile/ Portable Cylinder Systems 3
2.3.1 Oxy-Fuel Gases 3
3.0 Hazards of Compressed Gases 3
3.1 Common hazards of compressed gas cylinders 3
3.2.1 Toxic Gases 4
3.2.2 Inert Gases 4
3.2.3 Flammable/ Explosive Gases 5
3.2.4 Pyrophoric Gases/ Self Reactive Mixtures 5
3.2.5 Oxidising Gases 6
3.2.6 Oxy-Fuel Gases 6
3.2.7 Fluorinated Gases 6
3.2.8 Medical Gases 7
3.2.9 Corrosive Gases 7
4.0 Control Measures 7
4.1 Dedicated Gas Cylinder Stores 7
4.2 Storage in Laboratories and Associated Areas 7
4.3 Ventilation, Gas Monitoring and Detection 7
4.4 Transport and Delivery 7
4.5 Pressure Regulators and Accessories 7
4.6 Piped Systems 8
4.6.1 Installation of New Gas Systems 9
4.7 Personal Protective Equipment (PPE) 9
4.8 Oxy-Fuel Equipment 9
4.9 Flammable, Pyrophoric, Asphyxiant and Toxic Gases 10
4.10 Disposal of Gas Cylinders 10
4.11 Emergency Procedures 10
4.12 Information, Instruction and Training 10
5.0 Further Information 10

1.0 Introduction

All aspects of work involving compressed gases including system design, storage and use are subject to the risk assessment process. This health and safety standard has been created to help with the practical elements of completing the risk assessment.

This standard provides information on different gas types, the hazard they present and what needs to be considered when carrying out a risk assessment and will give examples of how to control the risks associated with gas systems and gas types.

This standard can be used alongside the chemical risk assessment process where the gas being used forms part of the practical activity and where new installations/ gases are to be used including system design.

2.0 Risk assessment for any activity involving compressed gases

The process for any risk assessment follows the same basic steps:

1. Identify the hazards associated with the compressed gases (considering the intrinsic properties of the gas concerned and the general hazards arising from stored energy).
2. Identify who may be harmed, how they may be harmed and the likely potential severity.
3. Decide upon suitable precautions or control measures to manage the risk. The preferred hierarchy should be to:
    - Prevent or minimise the risk of a gas being released from the system.
    - Disperse or dilute the gas to prevent it reaching unsafe levels.
    - Have warning systems in place where needed and emergency procedures.
    - As with all risk assessments the appropriate control measures will be a combination of controls not just one.
4. Record the risk assessment.
5. Review it:
    - This can be periodical (max validity is 2 years)
    - In the case of an adverse event then it needs to be reviewed immediately.
    - Where there is a change to the process, gas type, alteration of equipment, etc.

2.1 Risk Assessment

As previously mentioned, all aspects of work involving compressed gases including system design, storage and use are subject to the risk assessment process.

While using gas as a reagent or in any other capacity in a practical experiment you must include the gas as part of your chemical risk assessment. You should be using this chemical risk assessment template.

If you are simply using compressed air for activities such as inflating tyres, using the standard risk assessment template will suffice.

2.2 Manifold/ Fixed Gas systems

Where it has been determined that a manifold/ fixed systems is to be installed, the risk assessment for design and installation will be completed as part of a project within the projects team. However, the use of the gas following installation will need to be risk assessed by the owner of the system using the above methods.

2.3 Mobile/ Portable Cylinder Systems

Only inert and oxidising gases can be utilised in labs as a mobile/ portable cylinder systems and must follow the below risk assessment process.

2.3.1 Oxy-Fuel Gases

The only exception to this rule is oxy-fuel cylinders which can be used on trolleys, with appropriate controls and training in place. Oxy-fuel systems are better being used in areas specifically designed for them. However, due to the nature of how they are used it will not always be possible to bring an item to a designated area hence the need for them to be made mobile such as being placed on a trolley.

No one shall use oxy/fuel gas equipment unless they have received adequate training. The training should include the properties of the gases; The safe use of the equipment; Precautions to be taken; The use of fire extinguishers; The means of escape, raising the fire alarm and calling the Emergency Services.

Where flammable and oxidant gases are in use, a DSEAR risk assessment is required, prior to use.

3.0 Hazards of Compressed Gases

Compressed gases will have a combination of hazards associated with them, and some that all compressed gases share. Before using any gas, it is important to read the label and safety data sheet as this will contain information on hazard(s) for the specific gas. Below is a list of some of the hazards (this is not an exhaustive list).

3.1 Common hazards of compressed gas cylinders

Common hazards of compressed gases include:

Sudden release of stored energy - A physical impact leading to a sudden release of energy from compressed gas being stored.

Blast resulting in flying debris - A physical impact from parts of gas cylinders that fail or any flying debris resulting from a cylinder or pipework failure.

Impact from falling cylinders - This may occur during transit or during storage if not properly secured.

Exposure to a released gas - Specific hazards will vary depending on the nature of the gas. Non-toxic, non-corrosive gases may cause asphyxiation if they are able to displace oxygen from the atmosphere. The general exposure routes include:

- Inhalation - breathing in a gas that has been accidentally released from the cylinder, due to a broken valve, dropping of the cylinder or other means. Inhaled gases can be lethal depending on the gas type.
- Contact with skin or eyes - if gases make contact with eyes or skin, the gas can penetrate the tissue and make its way into the blood stream.

Workplace Exposure limits

The consequences of exposure to compressed gases will depend on both the intrinsic and hazardous properties and the concentration of the gas in the atmosphere. Some gases will have a Workplace Exposure Limit (WEL) assigned to them.

Workplace exposure limits (WELs) are occupational exposure limits approved by Health & Safety Executive (HSE). They are set to help protect workers' health. WELs are concentrations of hazardous substances in the air, averaged over a set period. WELS can be found under Exposure Controls section on the suppliers' safety data sheet (SDS).

EH40 Workplace exposure limits is a publication which contains a list of all current WELs. The list is legally binding under COSHH.

3.2 Specific Gas Hazards

3.2.1 Toxic Gases

A toxic substance is one which, in low quantities, can cause damage to living tissues, impairment of the central nervous system, severe illness, these can have acute or chronic effects and in some extreme cases death.

Depending on your work/research you may encounter various toxic gases during your time working at Swansea University. Examples of toxic gases include:

- Hydrogen Sulphide
- Carbon Monoxide
- Nitrogen Oxides
- Anhydrous Ammonia
- Ozone

If individuals are exposed to toxic gas, it can create a range of health issues. Acute exposure can also result in fatalities. Some serious health problems related to acute toxic gas exposure include:

- Airflow obstruction
- Acute upper airway inflammation
- Bronchiectasis
- Delayed pulmonary oedema

There are a few gases which may exhibit one or more of the hazards of carcinogenicity, mutagenicity, and reproductive toxicity (CMR). Where this is the case, information shall be given in the SDS under the hazard statement section and indicated on the gas container contents label.

3.2.2 Inert Gases

Inert gases are gases which are stable and generally unreactive unless under certain conditions, such as the addition of heat or pressure. Although asphyxiation hazards exist with any gas or gas mixture which does not contain sufficient oxygen to support life, this hazard is mainly associated with inert gases. These gases will displace the available oxygen in the air around you to a level which would be unsafe and may not support life.

Other than displacing oxygen these of gases tend to be is odourless, tasteless, and colourless which exacerbates their asphyxiant nature. Examples of inert gases:

- Argon
- Helium
- Nitrogen
- Carbon dioxide*

*Carbon dioxide has the additional hazard of hypercapnia. For carbon dioxide, fatal concentrations are created well before inert gas asphyxia conditions have a significant impact.

For normal working a 19.5% oxygen in air is needed, atmospheres containing less than 18% oxygen in air are potentially dangerous and must not be entered unless appropriate safety controls have been put in place. As stated previously any gases can be asphyxiant at atmospheric pressure apart from oxygen, air and gas mixtures manufactured specifically for breathing. Many gases will present other hazards such as being flammable or toxic and these are likely to cause an issue before the asphyxiation occurs.

3.2.3 Flammable/ Explosive Gases

Flammable/ explosive gases are gases which can form mixtures with air that will freely propagate a flame. The flammable range is normally defined as the range of concentrations of the gas in air which will propagate a flame. Mixtures of flammable gas(es) with air or other oxidants within the flammable range have the potential to explode. The severity of an explosion caused by the ignition of a flammable gas/ air or other oxidant mixture depends on several factors including the quantity and extent of enclosure or confinement of the gas mixture. Examples of flammable gases:

- Acetylene
- Hydrogen
- Methane

Flammability Limits

Where a flammable gas such as hydrogen mixes with an oxidizing gas such as pure oxygen or air it can react in an explosive manner, if the concentration of flammable gas is within certain limits. These limits are known as ‘explosion limits or flammability limits’ both terms are interchangeable.

If the concentration of the flammable gas is below the lower explosion limit (LEL), then there is no reaction due to lack of fuel. If the concentration is above the upper explosion limit (UEL), no reaction occurs due to a lack of oxidant. Within these limits, flame propagation is possible provided there is an ignition source.

These limits are not scientifically well-defined properties. For example, the ignition energy may depend on the size and shape of the reaction vessel, the type of ignition, and other details of the measurement procedure. There are standard procedures that must be followed carefully to ensure that the results obtained for different gases are comparable.

3.2.4 Pyrophoric Gases/ Self Reactive Mixtures

Pyrophoric gases are capable of self-ignition (i.e. do not require sources of ignition) and as such will burn in air (or other oxidants). Under some conditions, spontaneous ignition and/ or detonate may occur, resulting in the of a mixture of the pyrophoric gas with air or another oxidant which may be unstable and explosive. Examples of pyrophoric gases include:

- Arsine

- Diborane
- Phosphine
- Silane

3.2.5 Oxidising Gases

Oxidising gases are non-flammable gases which help support combustion. They include oxygen and those that are capable of spontaneously evolving oxygen at room temperature or with slight heating. Flammable gases and other combustible materials may spontaneously ignite when in the presence of strong oxidiser or high enough oxygen concentration in air. Some oxidising gases will support combustion more vigorously than air or oxygen.

Oxygen levels above 23.5 % create an oxygen enriched atmosphere which greatly increases the flammability of material. *Oxygen levels must not be allowed to exceed 25%.* Examples of oxidising gases include:

- Oxygen
- Nitrous oxide
- Fluorine
- Chlorine

3.2.6 Oxy-Fuel Gases

Oxy-fuel gases are those used for oxy-fuel welding and cutting, both processes use a fuel gas or liquid fuel and oxygen to weld or cut metals. Pure oxygen is used instead of air as this increases the flame temperature allowing the localized melting of the workpiece material. For Example a propane/air flame burns at about 1,980 °C but a propane/oxygen flame burns at about 2,253 °C, similarly a hydrogen/ oxygen flame burns at 2,800 °C and an acetylene/ oxygen flame burns at about 3,500 °C.

Other than the potential harm from the heat generated by the welding/ cutting and the flammability of the fuel and increased oxygen, below are some other hazards associated with this sort of use:

- Potential for acetone in the acetylene cylinder to leak out if more than 1/7 of the bottle is used per hour.
- Acetylene is unstable and explosively decomposes above 1 atm (15 psi) pressure.
- The welding or cutting process is likely to give off harmful chemical fumes such as metal oxides or carbon monoxide. It is important that there is adequate ventilation available when usings this type of equipment.
- Glare and flying sparks from the process can be hazardous so it is important that appropriate personal protective equipment such as welding goggles.
- There is a chance that the flame could propagate back down line (this is called a flashback) cause an explosion in the hose with the potential to injure or kill the operator. You would use a flashback arrestor to avoid this.

3.2.7 Fluorinated Gases

Fluorinated gases (F gases) are manufactured greenhouse gases that contribute to global warming and include:

- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulphur Hexafluoride (SF_6)

A Technical guidance note from sustainability can be found here which contains more information on F gases.

3.2.8 Medical Gases

Medicinal gases are classified as a medicine in compliance with *The Human Medicines Regulations.* Within a medical environment they must always be managed and controlled by an appropriately qualified healthcare professional. In a hospital this will be the Pharmacist. Information on managing medical gases at Swansea University can be found in the by contacting the compliance team in the Faculty of Medicine, Health and Life Sciences.

3.2.9 Corrosive Gases

A corrosive gas is one which, on contact with a person or other organic material may cause damage to the tissue such as skin, eyes, and mucous membrane. These gases might also react with non-organic materials such as metals, plastics etc. and cause damage to them leading to potential failure. Corrosive gases will only react with a material in the presence of moisture/ water in atmosphere or other source. In the event where a corrosive gas does corrode a material this can lead to the evolution of other gases such as hydrogen which can lead additional hazards.
Examples of corrosive gases include:

- Chlorine
- Chloride
- Sulphur dioxide
- Ammonia

4.0 Control Measures

4.1 Dedicated Gas Cylinder Stores

Please see University Health and Safety Standard for Gas Cylinder Storage.

4.2 Storage in Laboratories and Associated Areas

Please see University Health and Safety Standard for Gas Cylinder Storage.

4.3 Ventilation, Gas Monitoring and Detection

Please see University Health and Safety Standard for ventilation, monitoring, and detection.

4.4 Transport and Delivery

Please see University Health and Safety Standard for the following:

- Gas Deliveries and Collection by Gas Supplier
- Gas Cylinder Manual Handling Information Sheet.

4.5 Pressure Regulators and Accessories

Pressure regulators are important – select and obtain the correct equipment at the outset and reduce risks with ongoing care and maintenance. Essential points:

- Ensure the regulator is designed for use with the specific gas (or gas type).
- Ensure the regulator is correctly rated to cope with the cylinder pressure.
- Once a pressure regulator has been in service with a particular gas it shall remain in that gas service for the remainder of its life.
- Keep regulators clean and undertake a visual inspection each time prior to use.
- Do not force any regulator that does not fit and do not attempt 'homemade' repairs or modifications.
- Ensure the pressure adjusting screw is fully retracted before connecting the regulator to the cylinder. This will ensure that there can be no flow through the regulator when the cylinder valve is opened.
- Never use oil or grease on regulator threads - particularly with oxygen cylinders, which could result in a violent reaction.
- Do not use PTFE tape or jointing compounds on regulator threads to seal leaks. These are designed to be metal-on-metal connections and if fitted properly should not result in leaks. If a satisfactory connection cannot be made, contact a gas supplier representative.
- Regularly check for leaks using an approved leak detection fluid.
- Immediately replace any damaged or defective regulator.
- Regulators must be replaced or refurbished every 5 years (every 2 years for corrosive gases). Due to the potential for time-related deterioration of the internal components, this should be the case irrespective of the degree of use that the regulator has seen (i.e. it will apply even if the regulator has not been used). This requirement is an industry standard in the UK.
- When purchasing a new regulator, ensure that you are supplied with one having the requisite five-year (or two years for corrosives) shelf life. This must be carried out through the Faculty Technical and Operations Team as they will keep the records of all regulators.
- Ensure that regulators are checked and maintained in accordance with inspection guidance.
- Consider installing devices such as flow-stoppers. These devices detect excess flow rates and either shut off or drastically reduce the gas flow. They can be fitted to free standing regulators or as part of a piped system. They may not be suitable for every application but are inexpensive and thus a very cost-effective control measure.

Further information on pressure regulators and accessories: BCGA Code of practice 47: The safe use of individual portable or mobile cylinder gas supply equipment.

4.6 Piped Systems

The are various piped gas systems in the university and from a safety perspective this is the preferred route for all compressed gases. This preference is based on the fact they restrict the distribution of cylinders, remove them from populated workspaces and minimise manual handling operations. If the source cylinders are located externally to the building, an uncontrolled release is also easier to deal with than a similar event occurring inside a building.

Piped gas systems must be designed, installed, and maintained in accordance with all recognised standards and regulations, this also needs to follow the new gas system installation process flow. Piped systems comprise two components:

- The supply system. This is the part of the installation from the cylinder outlet to the main pressure regulator and must be capable of withstanding the maximum cylinder pressure. The system commonly contains numerous components such as pigtails, purge points, isolation valves, heaters, and vaporisers. There are often manual or automatic changeover devices to enable cylinder switching. This section of the installation is often (and preferably should be) located outdoors and the cylinder location kept under the storage conditions described earlier as for a dedicated cylinder store.

- The distribution system. This is the part of the installation from the main pressure regulator to the outlet point. It should be operated at a pressure below the maximum supply pressure and must be protected from over-pressurisation resulting from malfunctions within the system. This is achieved by employing pressure relief valves or bursting discs, the discharge from these devices should be directed to a safe place.

In addition to ensuring compliant design standards, all installations must be subject to suitable inspection and maintenance regimes and only operated by trained staff. Please see pressure system policy and Inspection and examination guidance.

4.6.1 Installation of New Gas Systems

All new gas systems must follow the new gas system installation process flow.

4.7 Personal Protective Equipment (PPE)

PPE is the least effective control measure because it only protects the wearer not the area. However, it may be required according to the circumstances:

- Laboratory coats or overalls will protect clothing while moving cylinders.
- Stout gloves and safety footwear will protect the hands and feet while moving cylinders.
- Eye protection should be worn while changing regulators.
- Steel toe capped with ankle support shall be worn when handling cylinders.

For certain specialist applications, full breathing apparatus may also be required – the need for this should be determined by risk assessment. If breathing apparatus is required, it must be adequately maintained and operated only by trained and certificated users who have been certified as medically fit for the purpose.

All PPE must be adequately stored (e.g. hooks, lockers, wall dispensers for safety spectacles, purpose-built boxes for breathing apparatus) if not it is likely to become damaged.

4.8 Oxy-Fuel Equipment

- The area where the equipment is to be used should be well ventilated. Combustion fumes can cause health effects and oxygen enrichment should be avoided due to the risk of enhanced combustion in the event of a fire.
- Appropriate eye protection is always essential to protect against heat, glare, and sparks.
- As with all gas equipment, training, user inspection (hoses, blowpipes, torches etc.) and periodic maintenance by a competent party is essential to ensure safe use.
- Flashback arrestors of a type suitable for the gas type and working pressure should be fitted as an additional safeguard.
- Suitably rated EX or ATEX related equipment for the activity established as part of the risk assessment process.

More detail can be found in BCGA CP7, including information on process hazards, equipment standards, system set up, maintenance and inspection requirements, using the equipment, closedown procedures and emergency actions.

4.9 Flammable, Pyrophoric, Asphyxiant and Toxic Gases

All the controls previously mentioned are relevant to flammable, pyrophoric, asphyxiant and toxic gases but due to their unique nature there are additional controls listed below:

- **Internal locations**- If any of these types of gases must be used internally then they are to be enclosed in appropriately fire related/explosion resistant cabinets, ventilated to atmosphere at a safe location outside the building.
- **Restricted access and minimising holdings**- It is important to restrict access to these areas and to minimise the number of cylinders present.
- **Purge gases** - Appropriate purge gases must be present to enable purging of the system. Under all circumstances that require this e.g. during supply container changeover and prior to maintenance on the system.
- **Flow limitation** - Automatic shut-off and / or flow limiting devices should be present on the supply system.
- **Flashback arrestors** - These devices must be employed in all circumstances where flammable gases are used, not just oxy-fuel systems.
- **Suitably rated EX or ATEX rated equipment** for the activity established as part of the risk assessment process.

More detail for users of flammable, pyrophoric or toxic gases can be found in BCGA CP18.

4.10 Disposal of Gas Cylinders

Follow waste guidance note for disposal of gas cylinders.

4.11 Emergency Procedures

Please see emergency planning guidance document.

4.12 Information, Instruction and Training

Please see gas training document.

5.0 Further Information

H&S webpage (Swansea University): **www.swansea.ac.uk/healthsafety/**

Health and Safety Executive (HSE) guidance: www.hse.gov.uk/pubns/

Health and Safety Legislation: www.legislation.gov.uk

British Compressed Gas Association code of practice: https://bcga.co.uk/pubcat/codes-of-practice/